Instream Limestone Sand Treatment of the Middle Fork Watershed

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Introduction

This presentation describes the work that has been done by the West Virginia Division of Natural Resources (WVDNR), the West Virginia Division of Environmental Protection (WVDEP), and others to treat acid mine drainage (AMD) and atmospheric acid deposition (AAD) in the Middle Fork Watershed. The presentation largely integrates and summarizes information contained in *Middle Fork River Limestone Treatment of Acid Mine Drainage,* a 39-page final project report authored by WVDNR personnel Pete Zurbuch, Ray Menendez, Janet Clayton, Bruce Evans, and Shelly Miller for the WVDEP in April, 2001. A very limited amount of additional information is included to broaden and extend the record on the Middle Fork project.

Project Background

In 1992, the State of West Virginia initiated a stream restoration program focused on streams impacted by AMD. Because mining issues were within the its statutory mission, the WVDEP was identified as the lead agency for the program. A committee was established to guide the efforts of the restoration program by prioritizing streams and recommending restoration methods. Representatives of state and federal agencies as well as the coal industry and environmental organizations participated on the committee.

The restoration committee quickly identified the Middle Fork River and the Blackwater River as the first two streams to be restored under the new program. In both cases, limestone application was the treatment of choice, but different application methodologies were chosen for the two streams. It was decided that the Middle Fork River would be treated with instream limestone sand application. The Blackwater River would be treated using a self-feeding, rotary drum facility. It was agreed that the WVDEP would provide all funding and some personnel for the projects. The WVDNR would provide conduct project studies and provide operational personnel for both projects. This remainder of this presentation focuses principally on the restoration efforts that have taken place in the Middle Fork watershed, with relevant inclusion of information from the Blackwater project.

The Middle Fork Watershed

The Middle Fork watershed encompasses 151 square miles in Barbour, Randolph, and Upshur Counties of north central West Virginia. Three tributaries form its headwaters south of Adolph in Randolph County. These are Kittle Creek, Rocky Run, and Birch Fork. These sub-sheds contain the Mead Westvaco research forest. The headwater tributaries originate at elevations up to 3,480 feet; they drop rapidly to 2,320 feet where they converge at Adolph. The river then flows north for 38 miles where it joins the Tygart Valley River in Barbour County at a point 11 miles upstream of Tygart Reservoir.

Principal tributaries to the Middle Fork River are, in descending order are Rocky Run, Kittle Creek, Birch Fork, Schoolcraft Run, Spice Run, Laurel Branch, Laurel Run, Pleasant Run, Stonecoal Run, Sugar Run, Three Forks Run, Cassity Fork, Lick Run, Long Run, Kettle Run, Right Fork, Laurel Creek, Gum Run, White Oak Run, Hell Run, Devil Run, Laurel Run, Hanging Run, and Swamp Run.

The lower 32 miles of the Middle Fork River have been severely polluted by AMD since 1970. Most of the AMD enters the River at the town of Cassity from Cassity Fork, with lesser amounts entering from downstream tributaries including White Oak Run, Hell Run, Devil Run, and Swamp Run.

Many of the Middle Fork's tributaries also lie in watersheds that receive substantial amounts of AAD and have soils with little natural ability to buffer that acidity. In the early 1990's, this was evidenced in an obvious way when a section of the Middle Fork River upstream of AMD entry became too acid for trout stocking until late in the spring.

By the mid-1990's, despite substantial mining reclamation efforts, the combined effect of AMD and AAD had eliminated sport fisheries and the associated recreational and economic benefits from much of the Middle Fork watershed. This was its condition when the restoration project began.

Instream Limestone Sand Methodology

The WVDNR has extensive experience with the use of instream limestone sand to restore fisheries in streams impacted by AAD. The agency and its partners have restored sport fisheries to 300 miles of 70 streams through annual applications of more than 7,000 tons of limestone sand.

The methodology is simple and effective. Total annual acid load is estimated from chemistry and flow data or by using a watershed-based model developed by the WVDNR. The tonnage of limestone sand required to neutralize the estimated acid load is applied to the stream by dumping truckloads of the sand from streamside access points. In the first year of application, the tonnage is applied at twice the estimated annual acid load in order to establish a reservoir of

limestone particles in the streambed. Thereafter, the application rate is equal to the estimated annual acid load. The limestone sand used is a high-quality product containing greater than 97% calcium carbonate, with a narrow range of particle sizes averaging 0.02 inches, or 0.425 mm. The WVDNR obtains limestone sand of this quality from the Germany Valley quarry of the Greer Limestone Company.

Once placed instream, limestone sand is distributed downstream by successive high flow events, leaving little visual evidence of its application a year later. In the stream, the specific particle size of the sand results in optimum abrasion and calcium dissolution over time, with nearly a one-to-one correspondence of tons of sand used to tons of stream acidity neutralized. Metals previously in solution are, of course, precipitated as solids with the increase in pH, but this is not visibly obvious in most AAD impacted streams and would occur even in the absence of limestone treatment, merely at some point further downstream.

The protocols for using limestone sand methodology in streams impacted by AMD may differ somewhat from those recommended for AAD impacted streams. Because the volume of limestone required to neutralize acidity in AMD impacted streams is be much greater than for AAD, optimum treatment for biological restoration of AMD streams may require monthly, rather than annual, treatment. That said, it is clear that streams receiving AMD from their tributaries can benefit from the use of either application protocol in the tributaries.

Limestone Sand Application in the Middle Fork

From 1993 to 1995, a pilot study was conducted in the Middle Fork watershed to assess the feasibility of using instream limestone sand applications to treat AMD. The results of that pilot study were very encouraging with neutralization of both AMD and AAD in affected streams. It was decided that instream limestone sand application would be less expensive than other currently used active and passive treatment methods, including rotary drum and powder doser systems. A full design for treatment of both AMD and AAD in the Middle Fork watershed was subsequently developed and approved by the WVDEP and other state and federal agencies.

The approved treatment design incorporated 41 treatment sites on 27 tributaries of the Middle Fork River. Seventy-five percent of the treatment sites were located on tributaries impacted by AAD; the remaining 25% of the sites were on AMD streams. The idea behind treating the AAD streams was to introduce additional alkalinity into these streams to help with downriver neutralization of AMD as well as for the benefit of their own fisheries, primarily brook trout. For the AMD streams, restoration of the tributary fisheries was less of a priority than was the mitigating the impact of these streams on their downstream receiving streams.

The treatment design was made possible by the fact that much of the watershed is under active management by the Mead Westvaco Corporation. As such, there are a number of high-quality logging roads in the watershed that provide streamside access for limestone sand application. That access is often available high in the watershed on headwater stream reaches. This is an ideal situation for limestone sand application. Multiple treatment locations, high up on headwater streams, increase the contact time, and thus the effectiveness, of the limestone sand methodology.

At each treatment site, a gravel pad was constructed to permit limestone trucks to dump their loads directly into the stream and to turn around as necessary. The average initial cost of constructing these sites in 1995 was $3,428 per site, ranging from $693 to $10,143 per site. Subsequent repair costs have increased the site costs somewhat. In 2001, it was estimated that, for a 20-year period, the amortized costs of all 41 sites would be $8,271 per year, or about $200 per site per year.

In 1995, these 41 sites received their first limestone sand applications. Deviating from previously established protocols, AAD streams received first-year limestone applications at four times their estimated annual acid load. This was done to introduce excess limestone that would reach the receiving streams upstream of the introduction of AMD. AMD streams were treated that first year at twice their estimated annual acid load. In total, almost 8,000 tons of limestone sand were applied to streams in the Middle Fork watershed in that first year. The average cost per ton of sand delivered was $24.50, resulting in a first-year total limestone sand cost of $194,795.

In subsequent years, limestone sand applications have averaged about 2,700 tons annually. The cost per ton of limestone sand delivered has increased to about $29 over the years, primarily as a result of Greer's increased transportation costs. Total limestone costs currently average about $80,000 annually for the project. Personnel costs for WVDNR and WVDEP to schedule and meet limestone trucks and to monitor treatment average about $5,000 annually. Adding the cost of treatment site maintenance, the State's estimated annual cost for the project is currently about $90,000.

Project Results

Following tributary and mainstem treatment with instream limestone sand, the chemistry of the Middle Fork River improved dramatically. At its mouth, mean pH improved from 4.9 before treatment to 6.8 after treatment. Mean net alkalinity improved from –962 before treatment to +1,444 after treatment. Thirty-five miles upstream at Adolph, and upstream of AMD impacts, mean pH improved from 6.1 to 6.8 and mean alkalinity from 39 to 253.

The biological results from treatment were equally dramatic. Benthic macroinvertebrate populations exhibited an overall increase in the number of individuals and an increase in the number of acid-intolerant taxa following treatment. Similarly, fish populations increased in virtually all treated and receiving streams. Trout populations increased dramatically, principally as a result of successful natural reproduction of brook and brown trout. Even upstream of the introduction of AMD, total fish biomass virtually doubled. Immediately after treatment, it was once again possible to stock trout in the upper section of the river in early spring without fear of acid-caused fish kills. Currently, some 5,000 pounds of trout are stocked in nine and one-half miles of river.

Benefit/Cost Ratios

The WVDNR estimates that, in total, the Middle Fork limestone sand project has restored 119 miles of the Middle Fork River and its tributaries. The unit cost of that restoration is thus approximately about $756 per mile per year. This is extremely cost-effective. The WVDNR uses an economic benefit figure of approximately $40,000 per mile per year for restored coldwater streams. At that rate, the benefits of restoring sport fisheries in the Middle Fork watershed exceed $4.75 million annually to the West Virginia economy. The resulting benefit/cost ratio of the Middle Fork project would be about 53 to 1.

By contrast, the Blackwater River project, utilizing the rotary drum and doser methodology, has an annual restoration cost of approximately ten times that amount, even when its $1 million capital construction cost is excluded. Excluding that construction cost, the Blackwater River project's benefit/cost ratio is about 6 to 1, a figure that is eminently respectable but pales by comparison to that for the limestone sand methodology used in the Middle Fork watershed.

Conclusion

By the mid-1990's, the Middle Fork River and many of its tributaries had been degraded by AMD and AAD to the point that many of its streams and rivers could not sustain aquatic life. The instream limestone sand project that was implemented by the WVDEP, the WVDNR, and their public and private sector partners substantially restored sport fisheries, and the associated recreational and economic benefits, to most of the streams in the watershed. The project was the most cost-effective route to that highly desirable end.